

# USING SOFIA TO INTRODUCE TEACHERS AND STUDENTS TO COSMIC RAY SCIENCE

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## ABSTRACT

The Stratospheric Observatory for Infrared Astronomy (SOFIA) will perform an extraordinary program in Astronomy and Earth Science. Concurrent with this scientific effort, it is possible to create an effort where teachers and students measure the rate of cosmic rays versus longitude, latitude, and altitude. While this endeavor will not create new scientific knowledge, it will provide an opportunity to teach thousands of students to actively participate in an exciting scientific venture. It will provide opportunities to motivate students to pursue scientific careers.

## INTRODUCTION

SOFIA is the Stratospheric Observatory for Infrared Astronomy - a world class astronomical observatory for infrared and submm astronomy. It is an airborne observatory with projected flight hours as much as 960 hours/year (8 hour nights) for 20 years. The Upper Deck may in the future facilitate experiments for serendipitous research during regular deployments. We propose that a small area on the Upper Deck be allocated to schools so that they can build a cosmic ray detector and then fly it on SOPHIA.

Two years ago, the National Research Council (NRC) enunciated 11 significant scientific questions at the intersection of physics and astronomy when they wrote a report entitled "Connecting Quarks to the Cosmos". The document provides a fascinating roadmap to the future of physics. The report says

"The questions now being asked about the universe at its two extremes—the very large and the very small—are inextricably intertwined, both in the asking and in the answering, and astronomers and physicists have been brought together to address questions that capture everyone's imagination."

The concepts contained in it include the foundations of matter, space and time, dark energy, and dark matter. The eleven questions are fundamental and the key to the future understanding of nature. Every educated citizen should be familiar with these ideas.

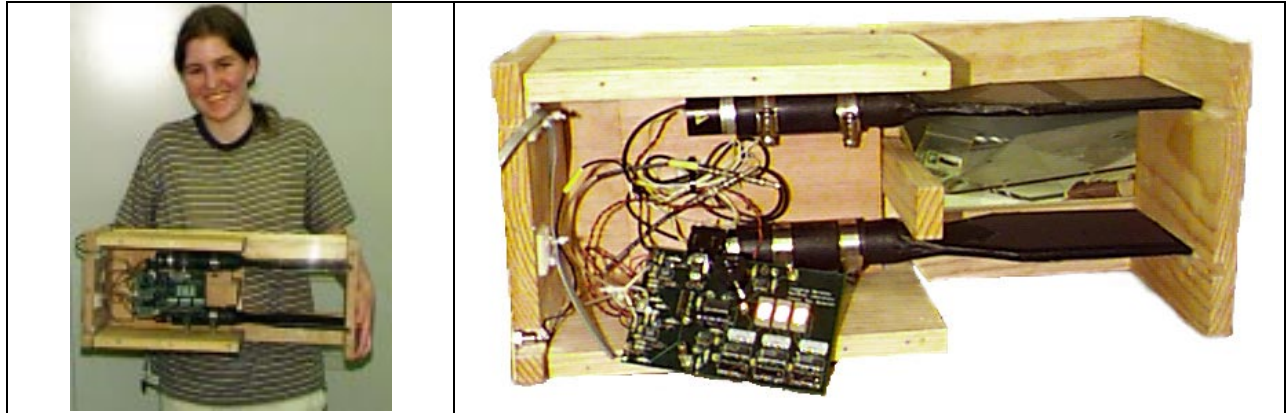
The experimental tests involve apparatus that are much too difficult for schools to replicate. However, one link to the physics described in the report is cosmic rays. Cosmic rays contain muons that can be readily detected. Muons arise from particles created in the sun, supernovae and other astrophysical objects. These particles are a step beyond the photon, neutron, proton and electron of which are the only matter conventionally taught in K-12 education. Using cosmic muons, one can begin to study the Universe and learn about its origin through a fascinating and exotic concept that can readily be understood, measured and understood on earth.

## THE BERKELEY COSMIC RAY DETECTOR

We have created a cosmic ray detector, which is small, inexpensive and easy to build. Almost 100 boards have been built at schools throughout the world. Students or teachers with a little electronic

training can easily assemble the detector. The detector draws little power and operates off a 12 V battery or an automobile outlet. This feature makes the device very portable.

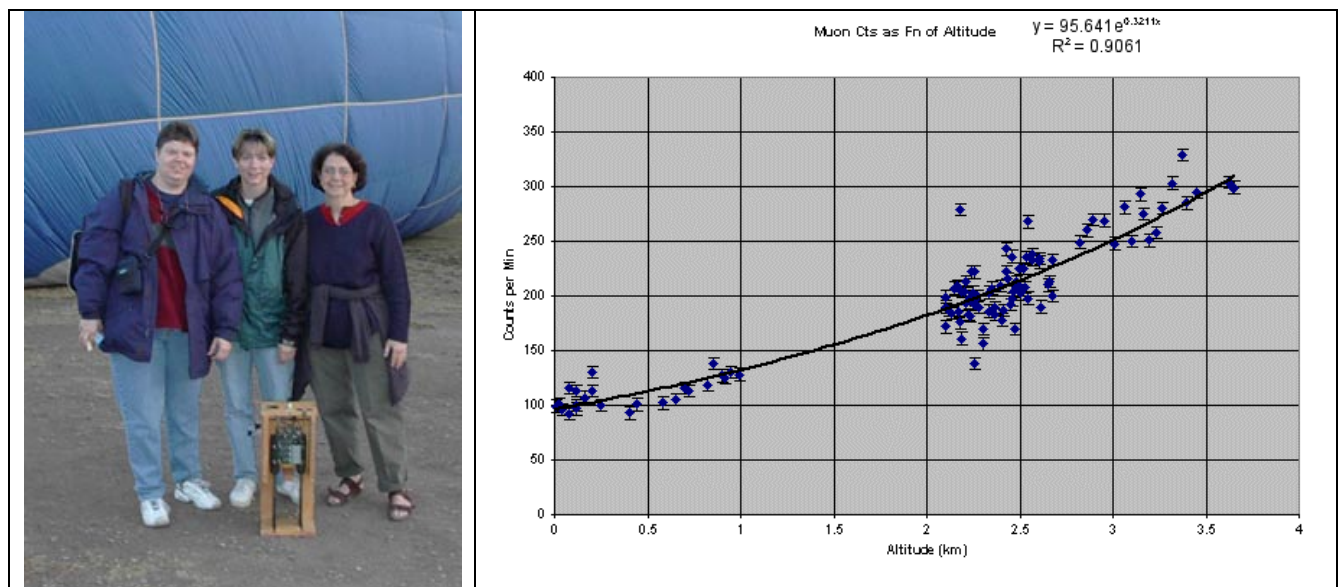
At sea level, the detector counts about 100  $\mu$ 's/min, so a 10% measurement can be made in one minute, while a 3% measurement can be made in 10 minutes. With this detector, several types of studies can be made such as the rate of cosmic ray production versus altitude and angle.



**Fig.1.** LEFT: A college student displays a detector that she built. RIGHT: The detector is partially disassembled to show its constituents.

## PREVIOUS USES OF THE DETECTOR

The Berkeley Detector has been focal point at many teacher workshops throughout this country. At these workshops teachers build their own device and then take it back into their school, where they use it in their classroom. While at the workshop, they attend lectures about the science of particle physics and cosmic rays.



**Fig.2.** LEFT: Teachers take the Berkeley Cosmic ray detector on a balloon flight to measure the cosmic ray flux. RIGHT: A measurement of Cosmic Ray flux versus elevation. This data taken was taken with the Berkeley Detector. A group of teachers drove the detector around the United States and recorded the altitude and cosmic ray rate. Ken Cerire provided this graph.

These detectors have been used almost everywhere. Participants have taken them into balloons, planes and onto mountains. They have been driven across this country. One was brought to the South Pole. This detector enables teachers and students an opportunity to glimpse the cutting edge of particle physics and astrophysics.

### PROPOSED PROGRAM WITH SOFIA

We propose that teachers and students apply to be a member of the cosmic ray team, at SOPHIA. Upon successful application, they will go through an orientation program to be briefed about SOPHIA's scientific program. At the first meeting, they will attend lectures and be briefed by scientists about its mission. There, they will be trained to build the detector. Upon completion of the introductory program, they will be given a kit with all materials to build a cosmic ray detector. They will take their cosmic ray kit back to the school and work with their students to assemble and test their detector. After the detector is completed, they will be assigned a flight on SOPHIA. Following the flight, their detector will be returned with the data, which they will analyze. Then, they will prepare a report on their results. Finally, there will be an assembly where each group will present their analysis to fellow members of the program. At this final meeting, they will listen to more lectures from SOPHIA scientists. Upon completion of the program, they will take back this knowledge and disseminate it to their school. Several outstanding teachers will be selected as master teachers to instruct the next generation.

### INSTRUMENTATION NEEDED ON THE SOFIA DECK

The resources needed to mount this program in SOPHIA are minimal. On each flight different groups will have an opportunity to fly their detector. Each detector is about two cubic feet. Power will be needed to supply one PC.

We propose that one data acquisition computer monitor several of these detectors. The computer will record, the time, latitude, longitude, elevation and detector angle for each cosmic ray. As the paths of the flights will be different, many different paths will be mapped. This information will provide a spectacular profile of the cosmic ray spectrum.

Each flight will bring a different set of detectors, so that many schools can be accommodated. Thus, the SOPHIA program will involve a large number of schools throughout this country.

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